Technical Report Documentation Page

1. REPORT No.

2. GOVERNMENT ACCESSION No.

3. RECIPIENT'S CATALOG No.

4. TITLE AND SUBTITLE

A Report On Testing Of Roadway Lighting Fluorescent Luminaire

5. REPORT DATE

December 1966

6. PERFORMING ORGANIZATION

7. AUTHOR(S)

Sedrekian, K.S.

8. PERFORMING ORGANIZATION REPORT No.

9. PERFORMING ORGANIZATION NAME AND ADDRESS

State of California
Department of Public Works
Division of Highways
Materials and Research Department

10. WORK UNIT No.

11. CONTRACT OR GRANT No.

13. TYPE OF REPORT & PERIOD COVERED

12. SPONSORING AGENCY NAME AND ADDRESS

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

A memorandum was sent on May 2, 1966, from Mr. E.R. Foley to Mr. John L. Beaton requesting the Materials and Research Department to run a series of tests on prototype fluorescent luminaires that are to be used in lighting of San Mateo-Hayward Bridge. After telephone conversations and meetings between Messrs. H.B. Thysell, L. Batiza, F. Kielian of Bay Toll Crossings and Messrs. J.E. Barton, R.L. Donner, and K.S. Sedrakian of Materials and Research Department, the following tests were performed and the result of each test was given to Mr. L. Batiza of Bay Toll Crossings:

1 Lamp Tests.
- a. Brightness measurements after 100 hours operation.
- b. Brightness measurements after 3600 hours operation.

2. Ballast Tests.
- a. Verification ballast starting at a minimum temperature of minus 5* F.
- b. Measurement of ballast operating tempurature at hottest spot on the ballast case.
- c. Measurement of lamp currents at bright and low level operation.
- d. Measurement of power-factor of ballast at bright and dim conditions.
- e. Accelerated ballast life tests.
- f. Ballast meaurements for circuit transients.
- g. Voltage and current measurements with dimming circuits of 2 ballasts connected in parallel.

17. KEYWORDS

18. No. OF PAGES:

35

19. DRI WEBSITE LINK

http://www.dot.ca.gov/hq/research/researchreports/1966-1967/66-45.pdf

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State of California
Department of Public Works
Division of Highways
Materials and Research Department

December 1966

San Mateo-Hayward Bridge
Contract 5026, 450.28 TX-5

Mr. E. R. Foley
Division of Bay Toll Crossings
151 Fremont Street
San Francisco, California

Dear Sir:

Submitted for your consideration is:

A REPORT ON

TESTING OF ROADWAY LIGHTING FLUORESCENT LUMINAIRE

Study made by . . . . . Structural Materials Section

Under direction of . . . . . E. F. Nordlin

Work supervised by . . . . . J. E. Barton and R. L. Donner

Report prepared by . . . . . K. S. Sedrakian

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

KSS:mw
Attach.
cc: JEWilson

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INTRODUCTION

A memorandum was sent on May 2, 1966, from Mr. E. R. Foley to Mr. John L. Beaton requesting the Materials and Research Department to run a series of tests on prototype fluorescent luminaires that are to be used in lighting of San Mateo-Hayward Bridge. After telephone conversations and meetings between Messrs. H. B. Thysell, L. Batiza, F. Kielian of Bay Toll Crossings and Messrs. J. E. Barton, R. L. Donner, and K. S. Sedrakian of Materials and Research Department, the following tests were performed and the result of each test was given to Mr. L. Batiza of Bay Toll Crossings:

1. Lamp Tests.
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   c. Measurement of lamp currents at bright and low level operation.
   d. Measurement of power-factor of ballast at bright and dim conditions.
   e. Accelerated ballast life tests.
   f. Ballast measurements for circuit transients.
   g. Voltage and current measurements with dimming circuits of 2 ballasts connected in parallel.
3. Prototype Luminaire Tests.
   a. Measurement of lens surface brightness.
   b. Candle-power distribution measurements.

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1. Lamp Test

The 4 Sylvania 96T12/CW/30° lamps were operated for 3600 hours, using 2 Sola Cat. No. 674-260 ballasts. The aperture surface brightness of the lamps was measured after 100 hours and 3600 hours of lamp operation, with lamp current of 700 ma. at 77° F ambient temperature. The results were as follows:

	100 Hours	3600 Hours
Lamp #1	15,000 ft-L	12,600 ft-L
Lamp #2	15,100 ft-L	12,600 ft-L
Lamp #3	14,900 ft-L	12,500 ft-L
Lamp #4	14,000 ft-L	11,500 ft-L

Note: The brightness at 100 hours was measured using Pritchard Photometer with 1/10° aperture plate at a distance of 5 feet. The brightness at 3600 hours was measured using Spectra Brightness Spot Meter UB½° with SL-20 supplementary lens at a distance of 12.6 inches. Previously we had verified that under the above conditions both meters measure the same area and give identical values.

2. Ballast Tests

a. The 4 General Electric ballasts Cat. No. 6G3799 operated the lamp in both low and bright level at -5° F, temperature without any visible difficulty.

b. The ballast operating temperatures at the hottest spot on the case at an ambient of 25° C. were as follows:

Ballast A	74° C
Ballast B	71° C
Ballast C	74° C
Ballast D	71° C

c. Lamp operating currents of each ballast were measured in both low level and bright level currents to both lamps, with 460 volts input to the ballasts. The results were as follows:

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	Current in Lamp Connected Between Red and Yellow Wires		Current in Lamp Connected Between Blue and Yellow Wires	
	Low Level	Bright Level	Low Level	Bright Level
Ballast A	157 ma	830 ma	126 ma	770 ma
Ballast B	138 ma	750 ma	120 ma	730 ma
Ballast C	172 ma	790 ma	180 ma	775 ma
Ballast D	135 ma	745 ma	136 ma	741 ma
Ballast E	143 ma	740 ma	135 ma	735 ma

d. Power factor of ballasts at 460 volts was as follows:

	Low Level	Bright Level
Ballast A	0.35 Leading	0.93 Lagging
Ballast B	0.35 Leading	0.92 Lagging
Ballast C	0.60 Lagging	0.54 Lagging
Ballast D	0.37 Leading	0.95 Lagging
Ballast E	0.48 Leading	0.94 Lagging

Note: Ballast C did not have the proper power-factor correction; Mr. Frank Kielian of your department took it back for further investigation.

e. Accelerated Lift Test.

Ballasts A, B, C, and D were switched for 120 hours in steps of 30 seconds duration per step from off to bright, to dim, to bright, back to off with no adverse results.

f. Circuit Transients.

We were not given the ballast impedance characteristic to obtain dummy impedance load equivalent to 150 ballasts; therefore, in talking with Mr. Frank Kielian of your department we decided to run some tests with the 4 ballasts that were available to us. Perhaps these tests might be of some value to you in projecting towards 150 ballast load. Pictures of typical waveshapes of current and voltage as seen on the oscilloscope are attached to this report with the following results:

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Starting Current Pictures Page 7

Starting currents of 20 times peak operating current were observed with one ballast; as more ballasts were connected in parallel the starting current kept dropping until with 4 ballasts in parallel the starting current was about 7 times peak current.

Voltage Waveshape Pictures Page 8

The 4 ballasts were connected in parallel and the power was switched on and off; no adverse voltage transients were observed.

g. Voltage and current measurements with dimming circuits of 2 ballasts connected in parallel as shown in Figure B of Page 9.

1. Switch A and B closed:

Control circuit voltage	240 volts

2. Switch A open; switch B closed:

Control circuit voltage	213 volts

3. Switch A open; switch B closed:

Lamp end voltages of ballast A

Yellow - Red	152 volts
Yellow - Blue	-0-

4. Switch B open; switch A closed:

Control circuit voltage	209 volts

5. Switch B open; switch A closed:

Lamp end voltages on ballast B

Yellow - Red	152 volts
Yellow - Blue	-0-

6. Switch A and B closed:

Current in ballast A lamp	130 ma.

7. Switch A closed; switch B open:

Current in ballast A lamp	210 ma.

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3. Prototype Luminaire

The results of candlepower distribution and brightness readings at 430 ma. and ambient temperature of 77° are as follows:

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Page

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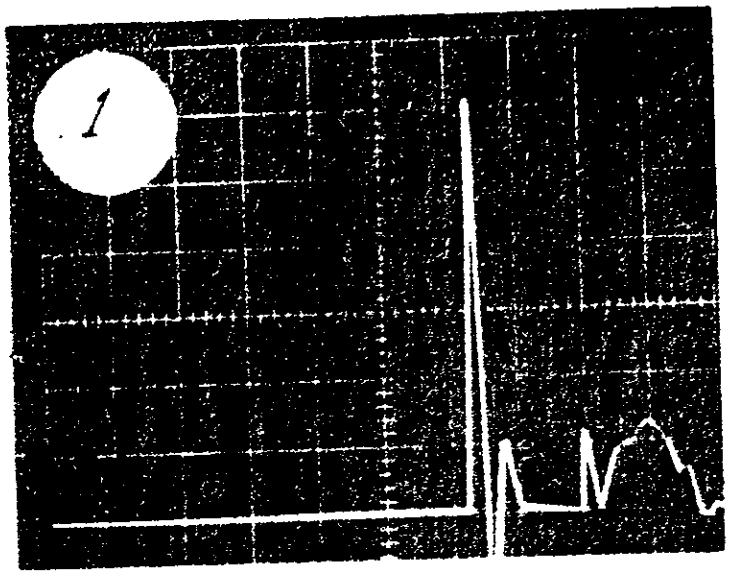

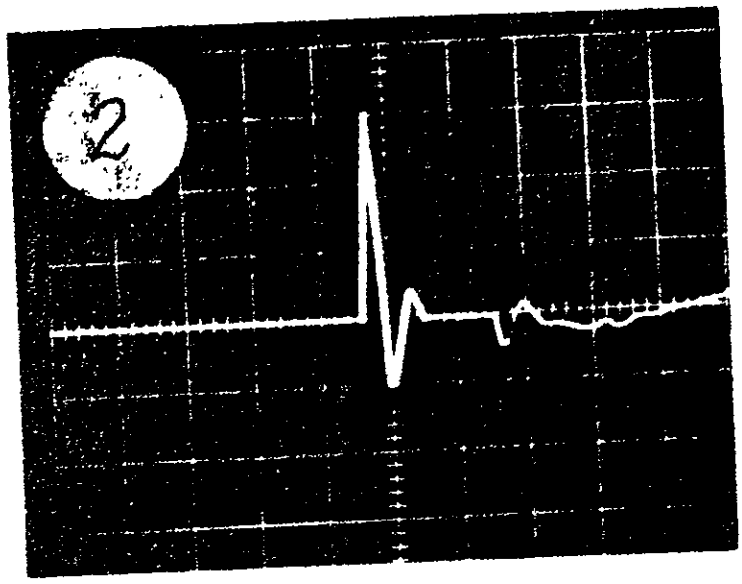

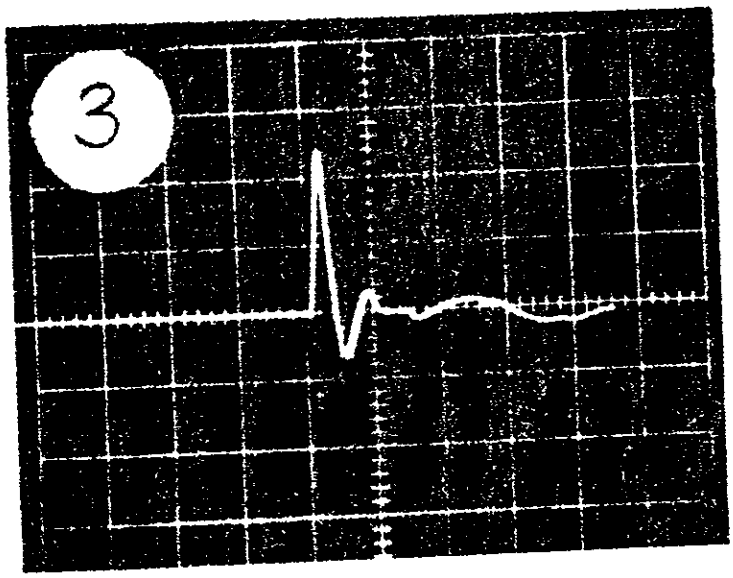

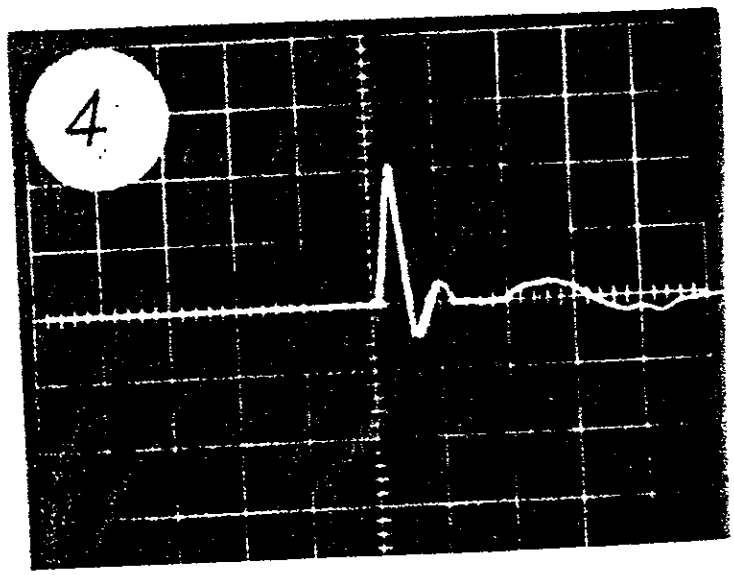

STARTING CURRENT

#1 - One Ballast

#2 - Two Ballasts

#3 - Three Ballasts

#4 - Four Ballasts

Time Base = 2 Milliseconds per Large Division

Peak Operating Current = 0.3 of Large Division

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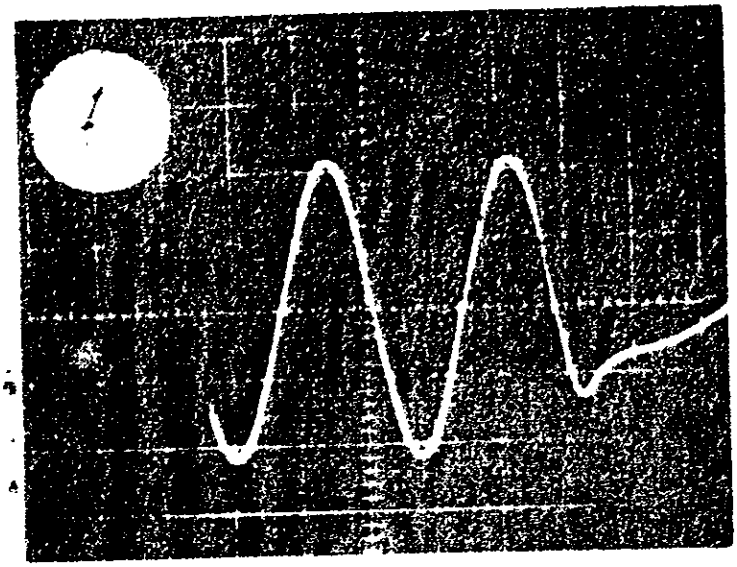

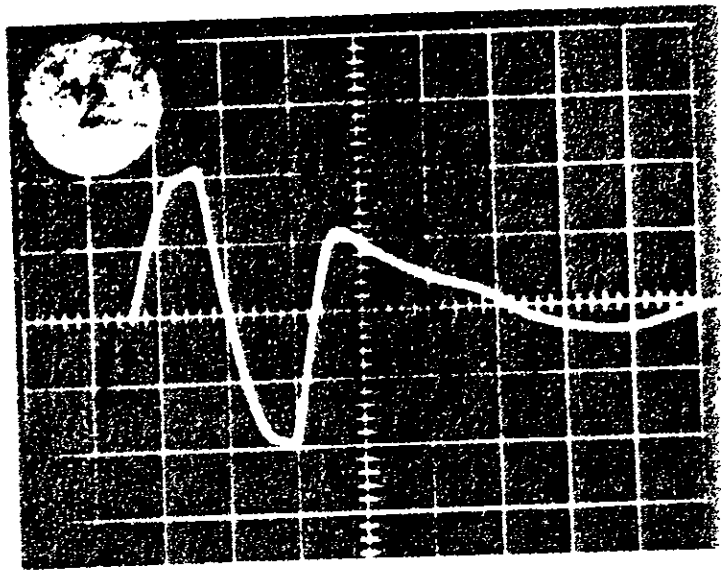

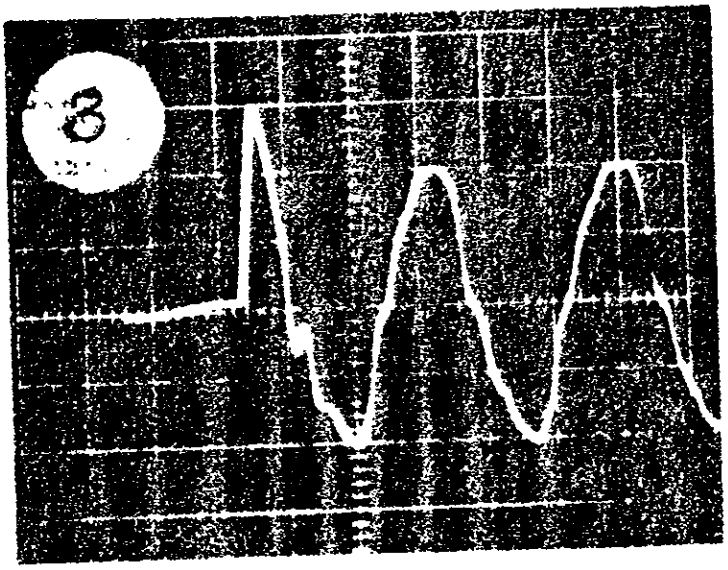

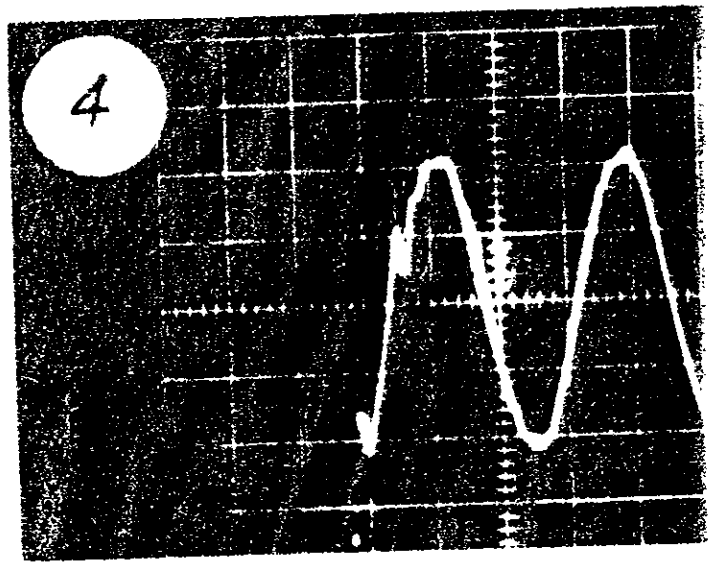

VOLTAGE

#1 & 2 - Power turned off
Four ballasts on one volt line

#3 & 4 - Power turned
Four ballasts on one volt line

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BALLAST TEST

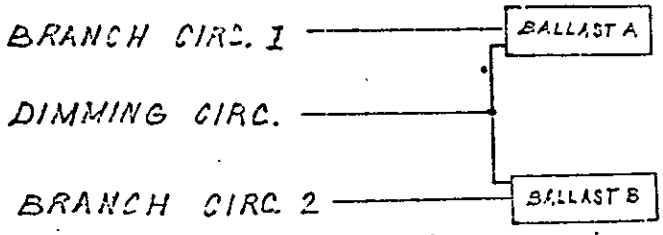

FIGURE A: TYPICAL ONE LINE DIAGRAM

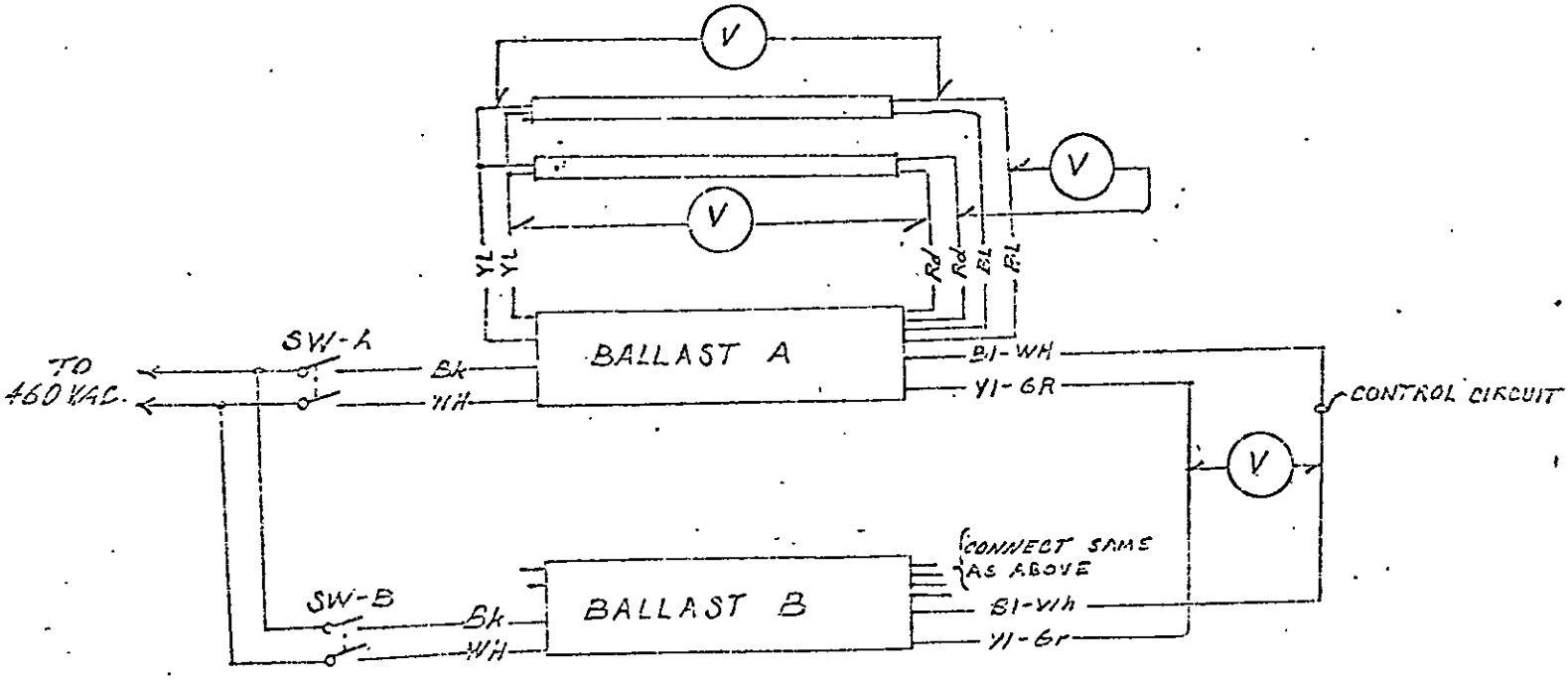

FIGURE B: BALLAST TEST SCHEMATIC

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Prototype Fixture
Holophane Lens

Lamp Aperture Horizontal
Lamp Current 430 ma.
Values in Candles

8-16-66

Vertical Angles	Horizontal Angles 90°	85°	80°	75°	70°	65°	60°	55°	50°	45°	40°	30°	20°	10°
+10°	671	650	612	561	491	411	336	259	192	146	117	70	42	21
-5°	756	734	682	619	539	459	381	315	255	180	137	80	43	20
0°	1511	1506	1445	1340	1207	1023	828	591	369	222	158	81	46	19
-2°	2770	2660	2440	2119	1778	1397	1013	679	396	220	144	71	41	18
-4°	3110	2970	2701	1356	1941	1537	1190	855	524	313	193	87	46	18
-5°	2610	2460	2247	1977	1675	1030	1126	849	609	402	246	93	51	20
-6°	1733	1682	1610	1511	1388	1213	1030	805	598	377	220	82	.41	19
-7°	1517	1503	1442	1335	1215	1083	952	788	615	448	280	94	46	19
-8°	1452	1411	1312	1211	1098	997	854	704	597	468	352	111	46	19
-9°	1369	1320	1236	1132	1027	895	777	656	539	451	372	146	53	20
-10°	1298	1263	1095	1098	964	846	713	628	520	437	353	123	47	20
-12°	1143	1114	1048	954	859	717	608	531	483	405	328	211	59	20
-16°	588	572	548	535	540	534	477	417	369	335	299	196	67	20
-20°	350	342	329	313	300	303	339	364	316	270	251	159	81	20
-25°	305	296	281	264	240	219	207	218	264	245	204	156	83	20
-35°	219	217	211	199	185	173	153	148	136	132	162	115	61	18
-45°	177	176	170	164	152	142	134	124	116	108	100	100	56	18

FIGURE 3

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Prototype Fixture
Holophane Lens

Lamp Aperture 15° Above Horizontal
Lamp Current - 430 ma

8-17-66

Values in Candles

Vertical Angles \ Horizontal Angles	90°	85°	80°	75°	70°	65°	60°	55°	50°	45°	40°	30°	20°	10°
+10°	532	517	490	455	410	352	294	229	164	134	105	67	40	18
-5°	830	797	730	650	553	457	368	292	226	171	132	74	40	16
0°	861	833	781	707	633	579	516	417	289	193	139	76	40	18
-2°	1336	1318	1247	1142	1014	852	680	478	301	188	130	68	40	15
-4°	2781	2638	2386	2079	1742	1345	976	639	377	233	156	77	40	18
-5°	3122	2951	2687	2348	1941	1533	1157	765	478	294	198	95	40	18
-6°	3055	2889	2609	2285	1878	1477	1102	762	470	258	164	76	40	16
-7°	2609	2449	2227	1988	1692	1392	1088	797	539	321	200	83	40	18
-8°	1896	1821	1708	1565	1408	1228	1036	823	624	410	253	98	45	19
-9°	1570	1524	1439	1336	1222	1097	954	815	632	492	323	109	45	19
-10°	1391	1308	1231	1151	1055	956	850	734	628	499	374	116	50	21
-12°	1195	1172	1117	1021	898	781	691	609	534	452	387	188	55	23
-16°	660	643	625	613	613	592	534	461	418	372	328	216	60	22
-20°	362	354	342	325	321	334	389	411	355	301	281	178	85	22
-25°	321	314	300	278	258	236	226	253	311	274	225	171	85	20
-35°	245	241	234	223	211	197	180	163	150	152	190	129	65	19
-45°	184	183	178	171	162	151	143	135	128	120	110	109	60	18

FIGURE 3

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Prototype fixture & Lens (Holophane)
8-30-66

Candlepower Distribution
Horizontal Angle — 90°

Lamp Aperture ⊄
Horizontal — 15° Above Horiz.

Lamp Label

Vertical Angles	Horizontal: Right	Horizontal: Left	Horizontal: Average	15° Above Horiz.: Right	15° Above Horiz.: Left	15° Above Horiz.: Average
+10°	580	730	655	495	585	540
+5°	950	815	880	920	885	900
0°	995	1860	1425	940	1045	990
-2°	1960	3565	2760	1085	1690	1390
-4°	3410	3620	3515	2380	3630	3005
-5°	3740	2550	3145	3240	3745	3490
-6°	3520	2030	2780	3720	3150	3435
-7°	2815	1885	2350	3690	2300	2995
-8°	1815	1780	1800	3025	1945	2485
-9°	1790	1620	1705	2320	1720	1970
-10°	1630	1510	1570	1690	1545	1620
-12°	1400	1390	1395	1470	1400	1435
-16°	710	670	690	950	830	890
-20°	390	405	400	410	415	415
-25°	345	360	350	375	360	370
-35°	175	255	215	300	270	285
-45°	210	205	210	210	205	210

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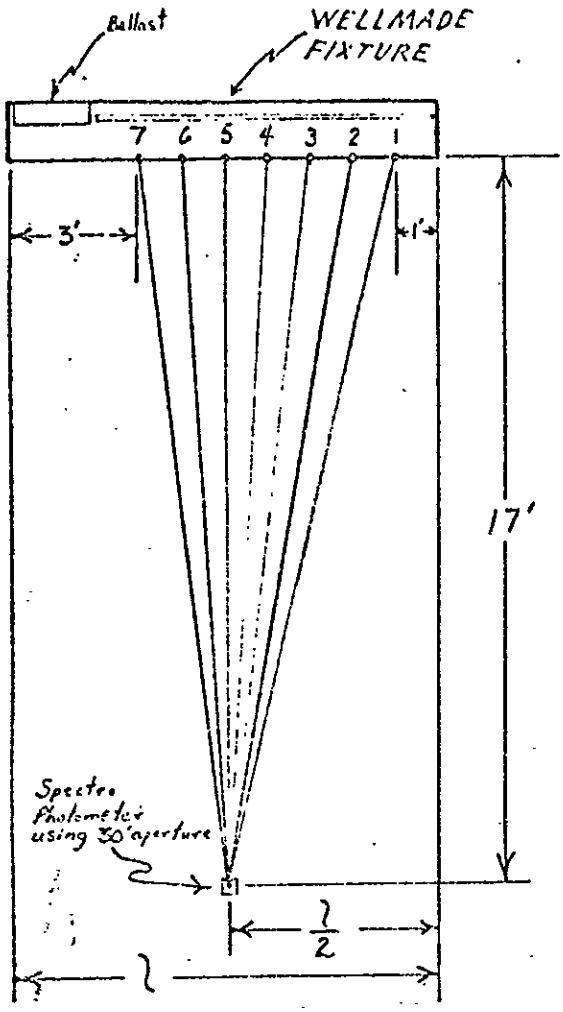
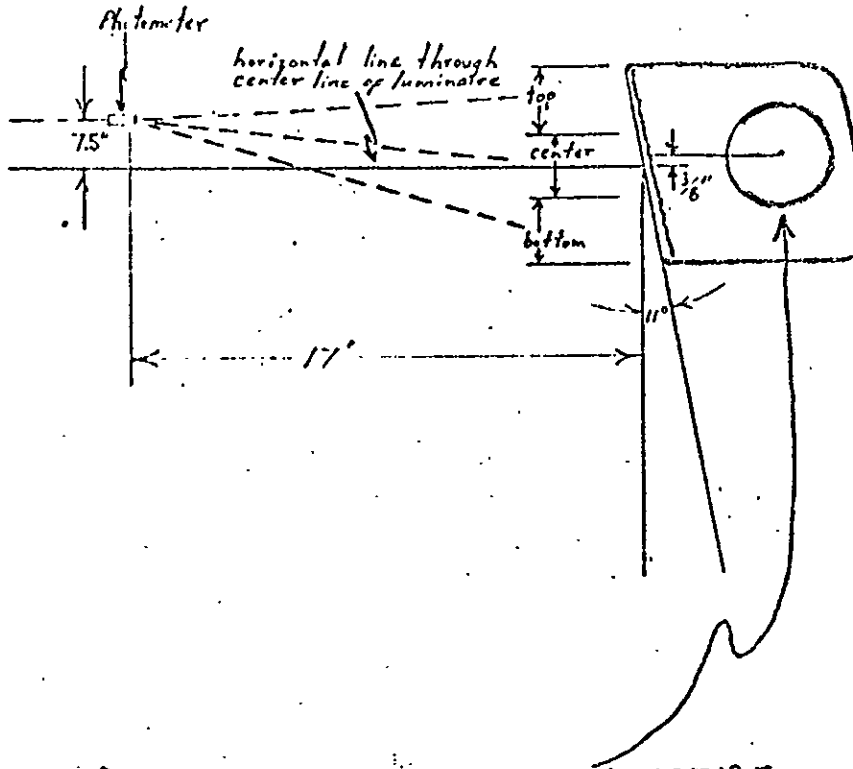
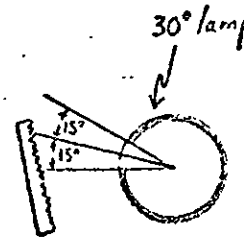




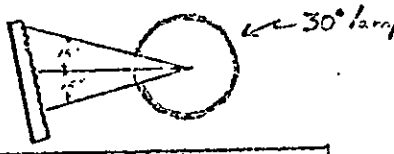
NOTE: LAMP LENS APERTURE SE
AS SHOWN BELOW FOR CORRESPONDING
TESTS.

Prototype fixture and Lens (Holophane) 8-30-66



I. Lens aperture of lamp beam at 15° up.

POSITION	1	2	3	4	5	6	7
TOP	440	490	530	600	600	640	660
CENTER	760	860	900	910	970	1030	1000
BOTTOM	590	620	680	730	730	700	730



II. Lens aperture of lamp beam at 0°

POSITION	1	2	3	4	5	6	7
TOP	530	550	550	680	720	640	910
CENTER	850	840	840	920	1100	1200	1700
BOTTOM	750	760	740	770	800	860	1400

LENS BRIGHTNESS IN FOOT LAMBERTS

Figure 1

FORM TX-301D
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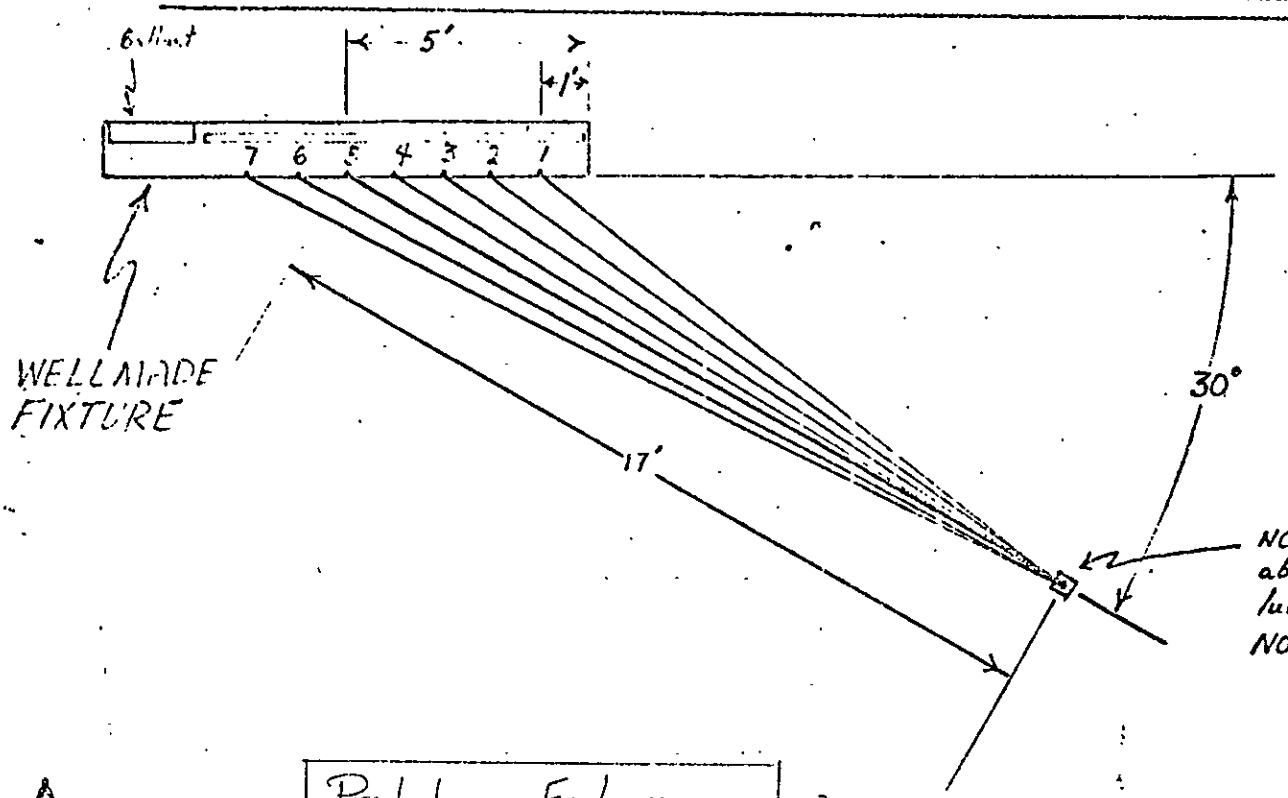
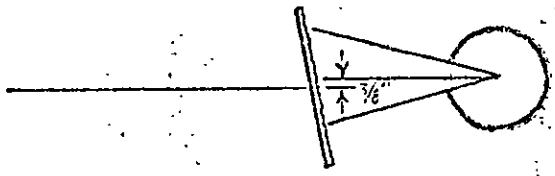


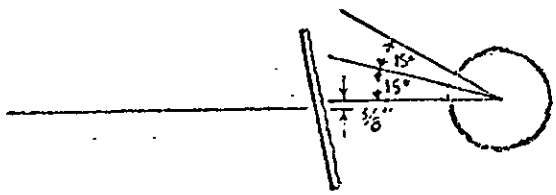
Prototype Fixture and Lens (Holophane)
8-30-66

FORM TX-301D



I. Lens aperture of lamp beam at 0°.

POSITION	1	2	3	4	5	6	7
TOP	180	180	120	120	100	98	18
CENTER	27	22	18	22	42	25	12
BOTTOM	18	18	18	18	13	12	6



II. Lens aperture of lamp beam at 15° up.

POSITION	1	2	3	4	5	6	7
TOP	170	210	160	150	140	103	26
CENTER	31	24	18	17	18	15	9
BOTTOM	19	20	16	13	14	13	7

LENS BRIGHTNESS IN FOOT LAMBERTS

Figure 2

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Prototype fixture with
Stimsonite Lens
8-30-66

Candlepower Distribution
Horizontal Angle — 90°

Lamp Aperture ∠

Horizontal — 15° Above Horiz.

Lamp Label

Vertical Angles		Right	Left	Average	Right	Left	Average
	+10°	385	660	520	425	550	485
	+5°	755	750	750	800	830	815
	0°	1050	1390	1220	850	915	885
	-2°	3130	3140	3135	875	1630	1250
	-4°	3545	3760	3650	2530	3470	3000
	-5°	3020	3600	3310	3260	3750	3505
	-6°	2085	2260	2170	3560	3500	3530
	-7°	1850	1790	1820	3595	2435	3015
	-8°	1740	1750	1745	2755	1920	2340
	-9°	1680	1685	1680	1755	1730	1840
	-10°	1515	1605	1560	1755	1650	1700
	-12°	1290	1350	1320	1535	1425	1480
	-16°	605	570	585	570	710	770
	-20°	340	370	355	365	350	370
	-25°	310	330	320	340	340	340
	-35°	235	240	240	270	250	260
	-45°	190	190	190	210	205	210

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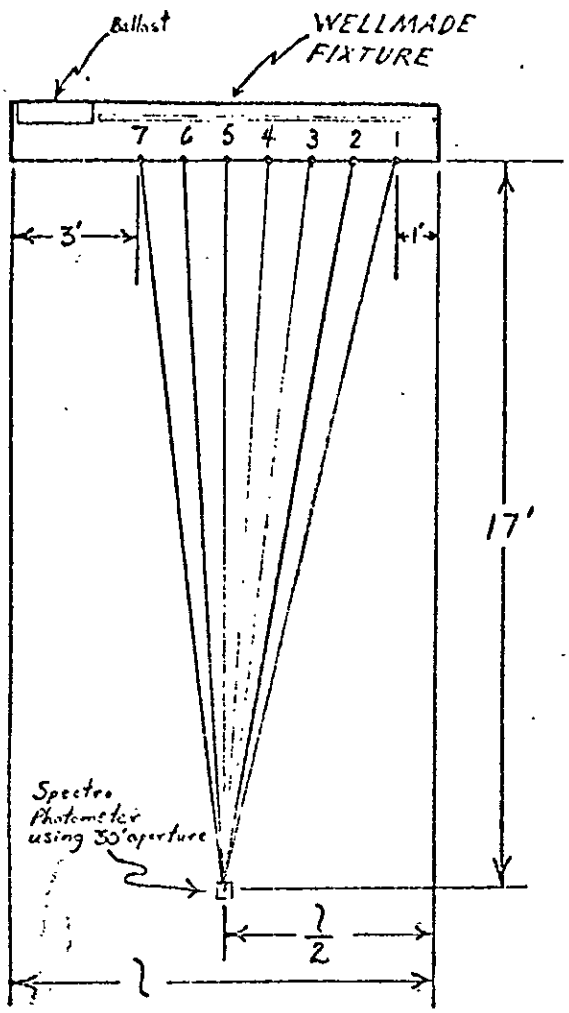
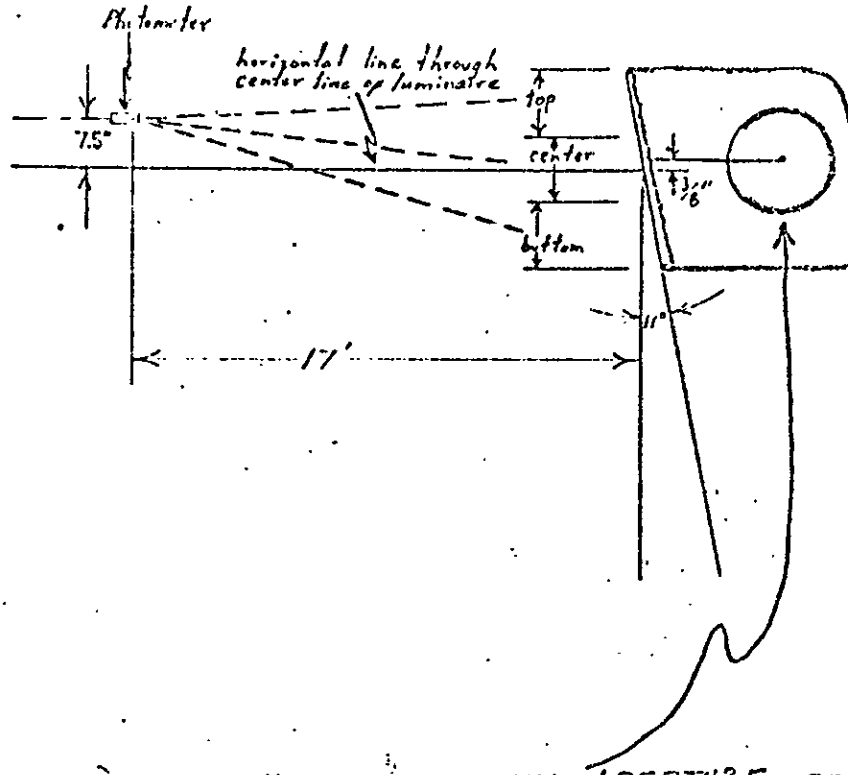
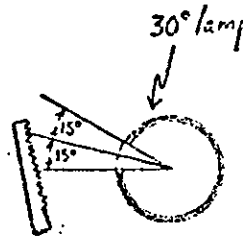




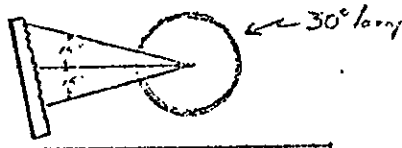
NOTE: LAMP LENS APERTURE SE
AS SHOWN BELOW FOR CORRESPONDING
TESTS.

Prototype fixture with
Stimsonite Lens
8-30-66



I. Lens aperture of lamp beam at 15° up.

POSITION	1	2	3	4	5	6	7
TOP	435	460	510	535	515	540	540
CENTER	660	770	835	885	935	955	900
BOTTOM	515	605	600	695	715	715	645



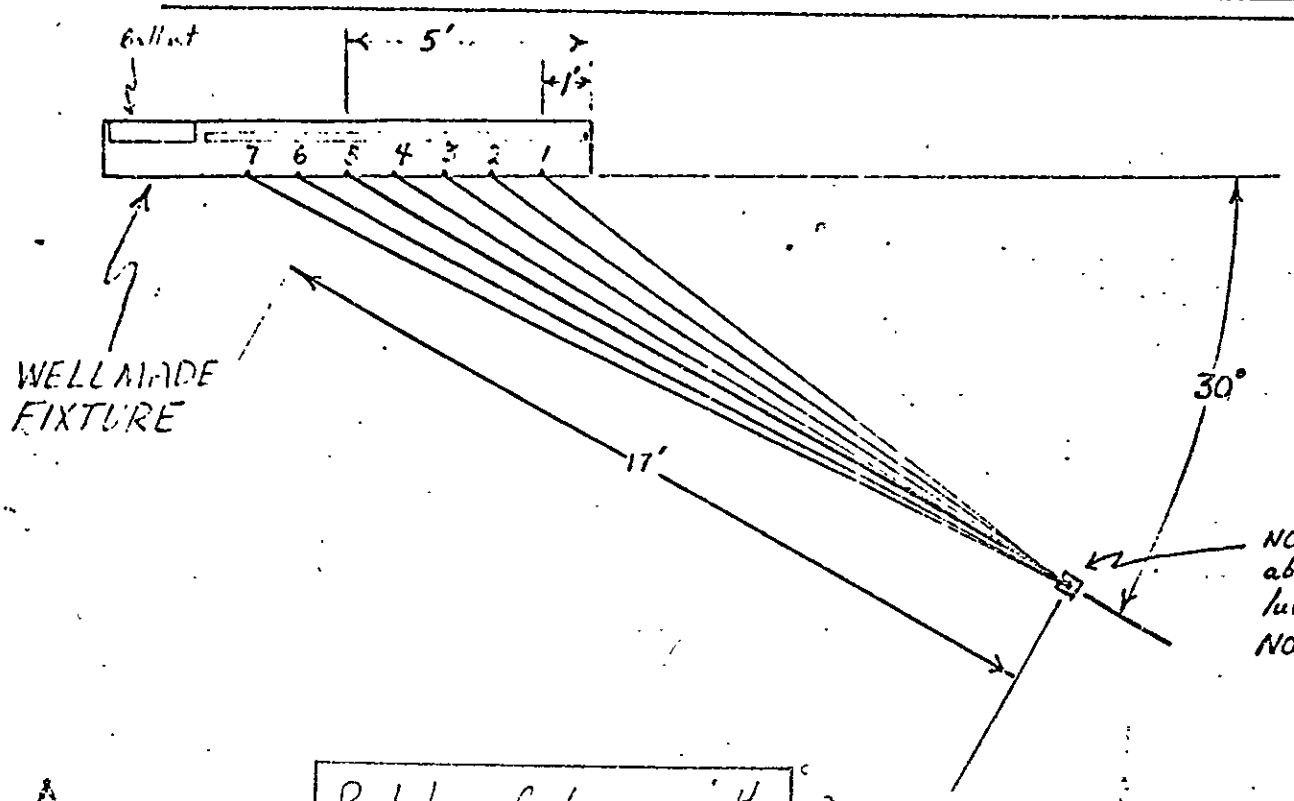
II. Lens aperture of lamp beam at 0°

POSITION	1	2	3	4	5	6	7
TOP	385	430	450	425	430	475	475
CENTER	615	740	840	890	895	930	895
BOTTOM	550	640	655	720	760	770	720

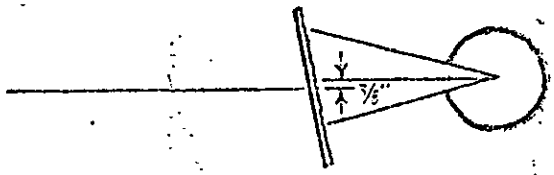
LENS BRIGHTNESS IN FOOT LAMBERTS

Figure 1

FORM TX-3010
ESCO 4-63 1800 SFO
ClibPDF - www.fastio.com

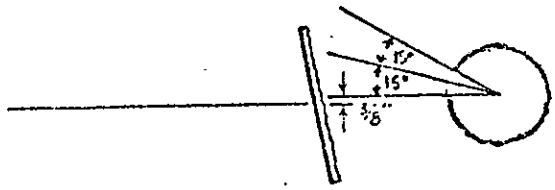


Prototype fixture with Stimsonite Lens
8-30-66



I. Lens aperture of lamp beam at 0°.

POSITION	1	2	3	4	5	6	7
TOP	185	135	110	150	145	85	65
CENTER	20	18	18	20	16	15	12
BOTTOM	14	20	15	14	14	13	12



II. Lens aperture of lamp beam at 15° up.

POSITION	1	2	3	4	5	6	7
TOP	175	145	135	140	140	105	70
CENTER	22	24	23	20	30	26	15
BOTTOM	17	21	15	14	15	14	13

LENS BRIGHTNESS IN FOOT LAMBERTS

Figure 2

FORM TX-3C10
85828 4-65 1500 BPO
ClibPDF - www.fastio.com

Lampholder Lowered 3/8"
and Moved Forward 1/8"
Holophane Lens
8-29-66

Candlepower Distribution
Horizontal Angle — 90°

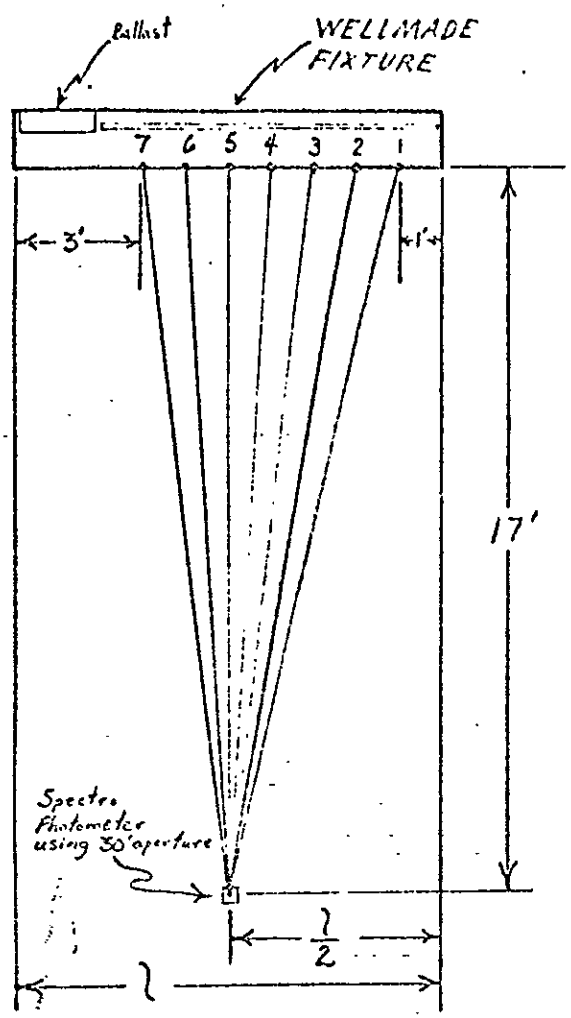
Lamp Aperture ⊄

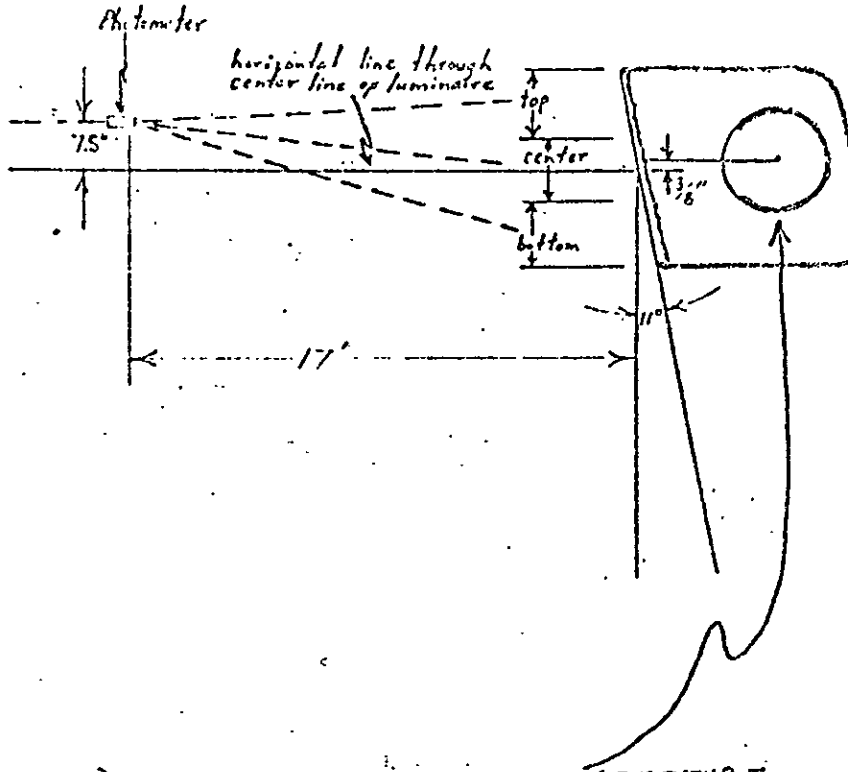
Horizontal — 15° Above Horiz.

Lamp Label

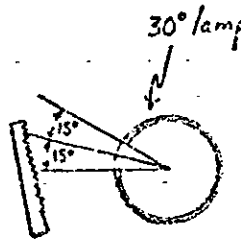
Vertical Angles	Horizontal Right	Horizontal Left	Horizontal Average	15° Above Horiz. Right	15° Above Horiz. Left	15° Above Horiz. Average
+10°	660	660	660	650	660	655
+5°	940	825	885	830	790	810
0°	3215	3090	3165	1355	1755	1555
-2°	2620	3100	2860	3075	3370	3225
-4°	1715	1835	1775	3420	2990	3205
-5°	1620	1675	1650	2510	2210	2360
-6°	1515	1610	1560	1900	1895	1900
-7°	1295	1440	1420	1655	1535	1595
-8°	1305	1350	1330	1330	1340	1335
-9°	1245	1265	1255	1280	1300	1290
-10°	1120	1230	1175	1280	1260	1270
-12°	910	1030	970	1080	1050	1065
-16°	420	440	430	465	470	470
-20°	330	350	340	355	370	360
-25°	310	320	315	330	330	330
-35°	235	250	240	270	280	275
-45°	190	190	190	205	205	205

-ClibPDF - www.fastio.com





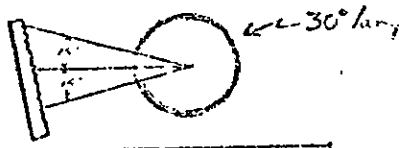
NOTE: LAMP LENS APERTURE SE
AS SHOWN BELOW FOR CORRESPONDING
TESTS.



Lampholder Lowered 3/8"
and Moved Forward 1/8"
Holophane Lens
8-29-66

I. Lens aperture of lamp beam at 15° up.

POSITION	1	2	3	4	5	6	7
TOP	480	515	560	535	560	595	675
CENTER	670	790	820	865	905	900	1150
BOTTOM	515	615	650	700	780	760	665



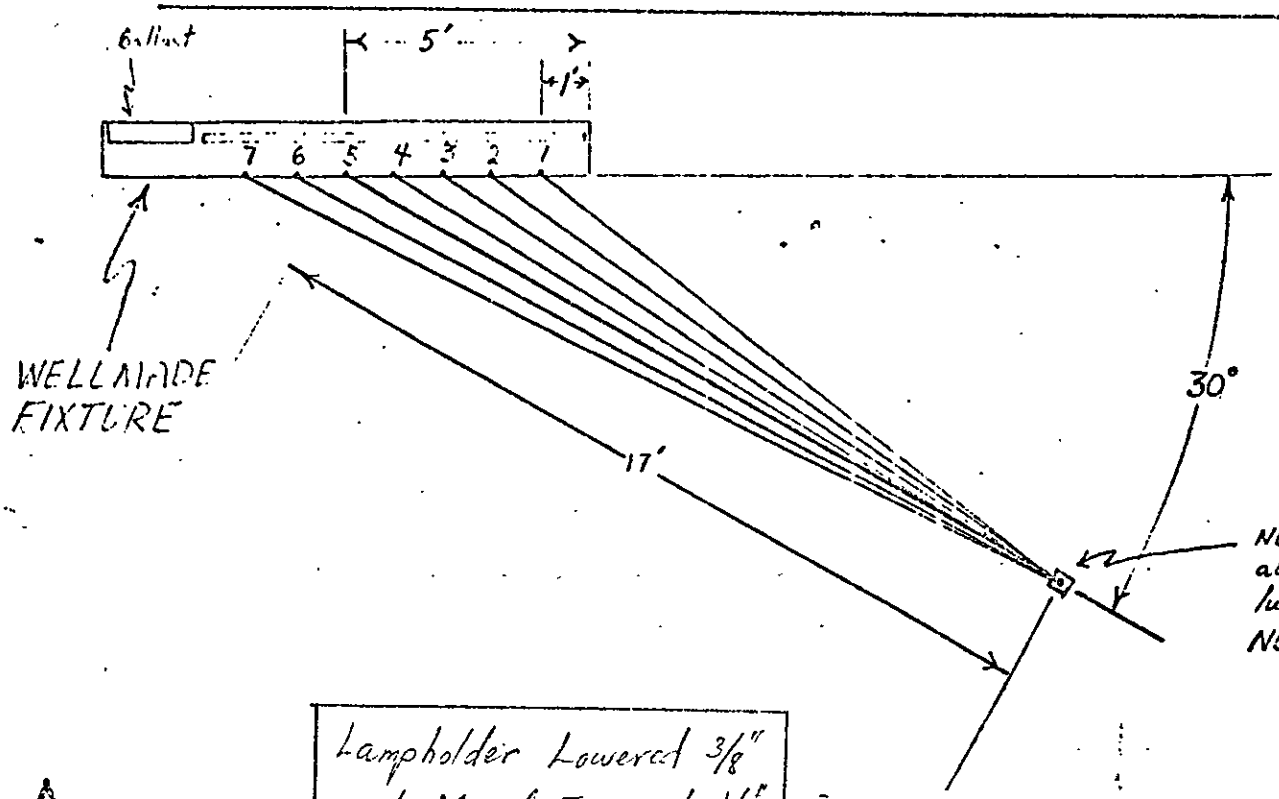
II. Lens aperture of lamp beam at 0°

POSITION	1	2	3	4	5	6	7
TOP	1350	1200	1080	1350	1600	1950	1850
CENTER	3700	3500	3600	3550	4400	5000	5000
BOTTOM	1500	1320	1370	1530	1650	1800	2200

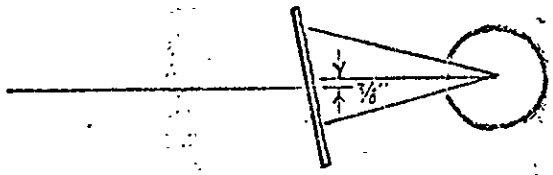
LENS BRIGHTNESS IN FOOT LAMBERTS

Figure 1

FORM TX-301D
85628 4-63 1500 STO
ClibPDF - www.fastio.com

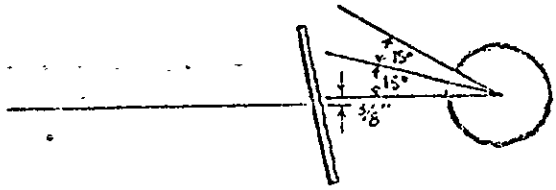


Lampholder Lowered 3/8" and Moved Forward 1/8" Holophane Lens 8-29-66



I. Lens aperture of lamp beam at 0°.

POSITION	1	2	3	4	5	6	7
TOP	175	160	130	120	120	100	19
CENTER	20	22	22	22	19	17	7
BOTTOM	15	17	12	12	13	10	5



II. Lens aperture of lamp beam at 15° up.

POSITION	1	2	3	4	5	6	7
TOP	185	175	45	125	135	105	19
CENTER	21	18	11	11	23	15	7
BOTTOM	14	17	7	12	11	11	5

LENS BRIGHTNESS IN FOOT LAMBERTS

Figure 2

FORM TX-3010
85828 4-63 1500 BPO

ClibPDF - www.fastio.com

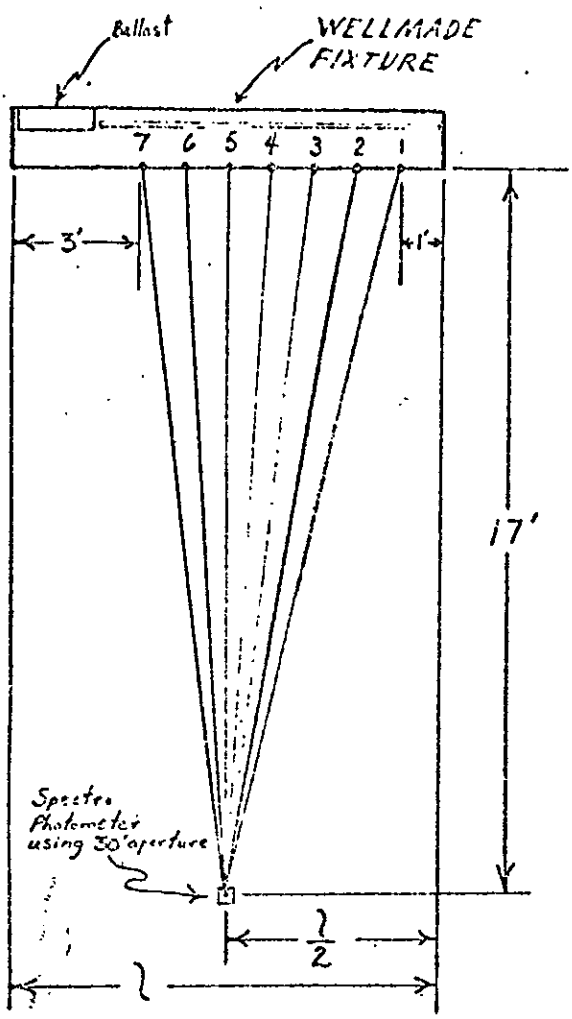
Lampholder Louvered 2/8"
and Slored Forward 1/8"
Stimsonite Lens
8-29-66

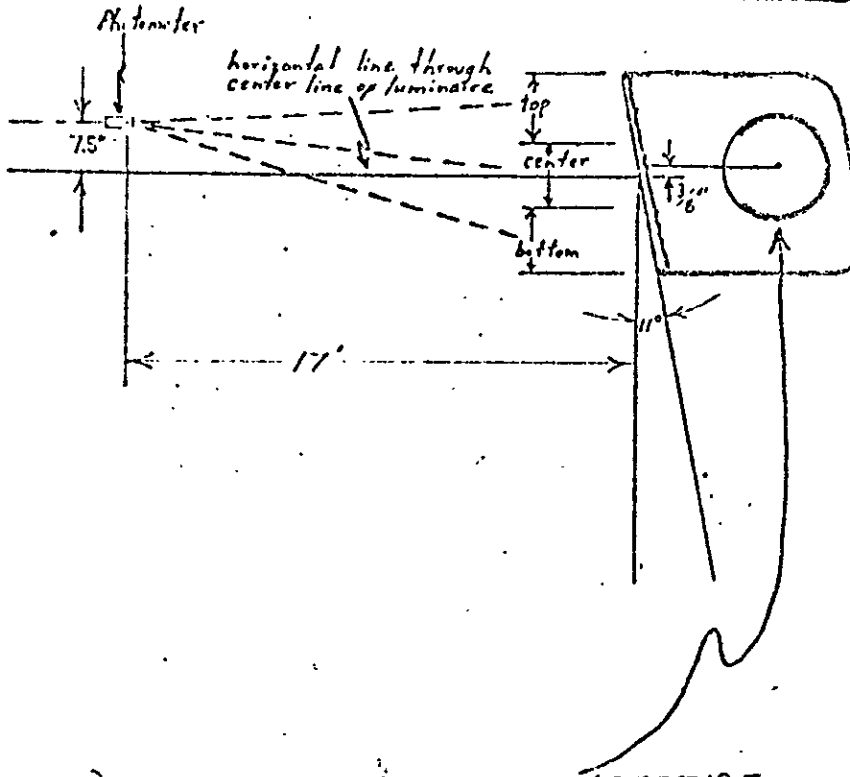
Candlepower Distribution
Horizontal Angle — 90°

Lamp Aperture ℄
Horizontal — 15° Above Horiz.

Vertical Angles	Lamp Label	Right	Left	Average	Right	Left	Average
	+10°	655	680	670	760	745	750
	+5°	800	840	820	805	805	805
	0°	3220	3190	3205	3065	2730	2900
	-2°	2420	2480	2450	3590	3640	3615
	-4°	1675	1660	1670	2280	2435	2360
	-5°	1615	1540	1580	1840	1865	1850
	-6°	1545	1570	1530	1680	1680	1680
	-7°	1425	1395	1410	1490	1535	1510
	-8°	1345	1335	1340	1400	1415	1410
	-9°	1305	1265	1285	1345	1425	1385
	-10°	1240	1195	1220	1280	1335	1310
	-12°	990	975	980	1100	1090	1095
	-16°	375	380	380	415	445	430
	-20°	310	315	315	330	355	340
	-25°	295	305	300	305	320	310
	-35°	230	225	225	265	260	260
	-45°	180	180	180	195	200	200

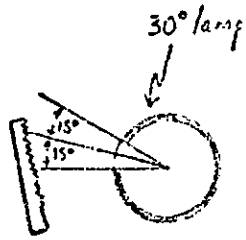
ClibPDF - www.fastio.com





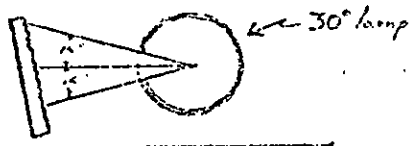
NOTE: LAMP LENS APERTURE SET AS SHOWN BELOW FOR CORRESPONDING TESTS.

Lampholder Lowered 3/8"
and Moved Forward 1/8"
Stimsonite Lens
8-19-66



I. Lens aperture of lamp beam at 15° up.

POSITION	1	2	3	4	5	6	7
TOP	570	580	615	570	680	690	1300
CENTER	1100	1000	1100	1150	1600	1700	3750
BOTTOM	660	715	735	840	825	860	1200



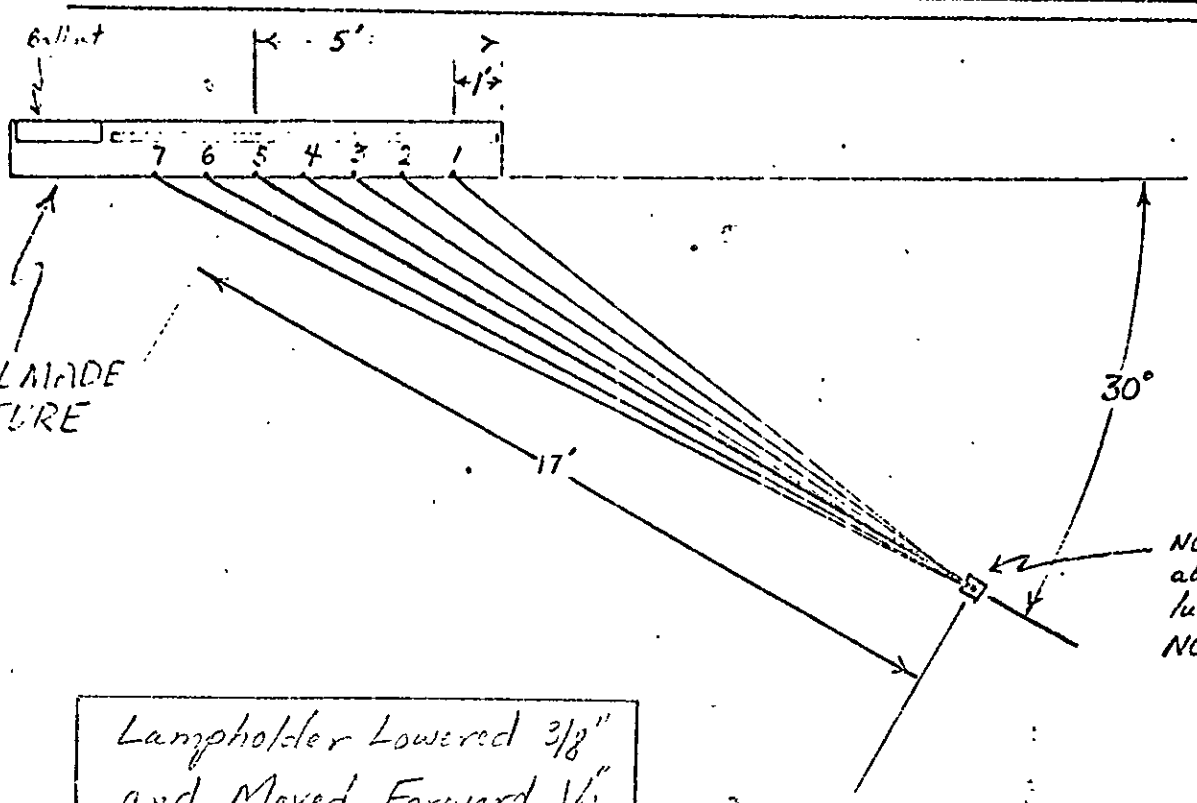
II. Lens aperture of lamp beam at 0°

POSITION	1	2	3	4	5	6	7
TOP	1500	970	805	1420	1800	1500	2100
CENTER	4750	3600	3400	4350	6100	6150	5650
BOTTOM	2450	1950	1130	1950	2650	2600	2350

LENS BRIGHTNESS IN FOOT LAMBERTS

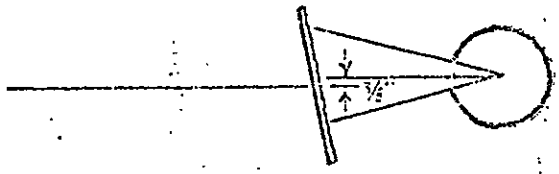
Figure 1

FORM TX-301D
85625 4-69 1800 STD
ClibPDF - www.fastio.com



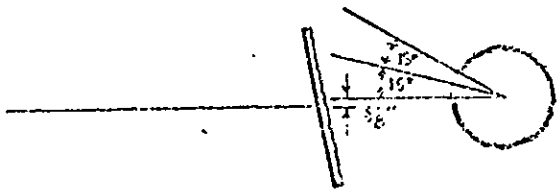
Lampholder Lowered 3/8" and Moved Forward 1/8" Stimsonite Lens
8-29-66

FORM TX-301D



I. Lens aperture of lamp beam at 0°.

POSITION	1	2	3	4	5	6	7
TOP	205	180	150	165	200	145	75
CENTER	30	30	30	25	30	28	22
BOTTOM	26	28	18	20	20	18	17



II. Lens aperture of lamp beam at 15° up.

POSITION	1	2	3	4	5	6	7
TOP	160	155	140	145	170	135	70
CENTER	20	25	30	22	26	26	17
BOTTOM	18	16	13	15	15	14	14

LENS BRIGHTNESS IN FOOT LAMBERTS

Figure 2

ClibPDF - www.fastio.com

Prototype Fixture
Inside Painted Black
Holophane Lens
8-29-66

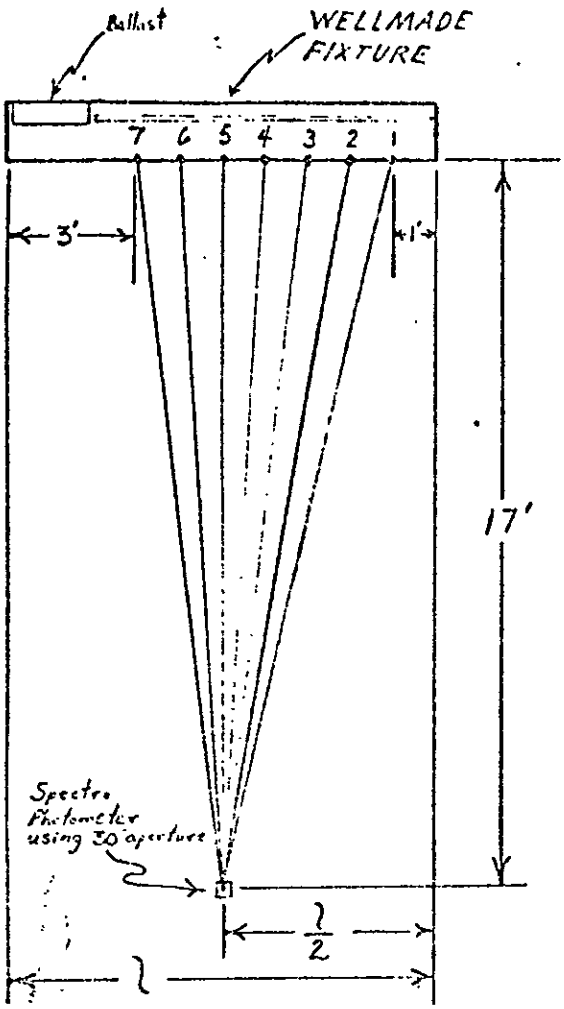
Candlepower Distribution
Horizontal Angle — 90°

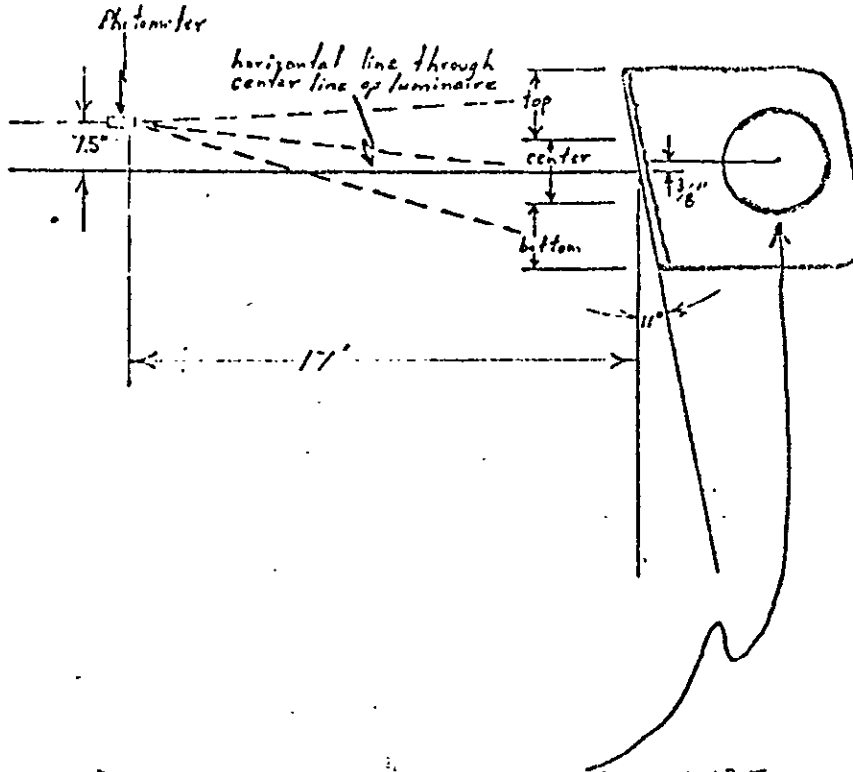
Lamp Aperture ⊄
Horizontal — 15° Above Horiz.

Lamp Label

Vertical Angles	Right	Left	Average	Right	Left	Average
+10°	330	400	365	220	275	245
+5°	515	535	525	570	525	550
0°	765	855	810	630	630	630
-2°	2220	2620	2420	680	865	760
-4°	3370	3470	3430	1270	2210	1740
-5°	3540	3660	3600	2425	3245	2835
-6°	2910	2560	2735	3070	3540	3305
-7°	2390	1915	2150	3460	3375	3420
-8°	1815	1595	1705	3425	2410	2920
-9°	1600	1490	1545	2100	1755	1928
-10°	1430	1440	1435	1650	1450	1550
-12°	1080	1100	1090	1180	1170	1175
-16°	435	375	405	690	575	630
-20°	110	120	115	120	125	125
-25°	80	85	85	85	85	85
-35°	60	65	65	65	65	65
-45°	60	60	60	60	60	60

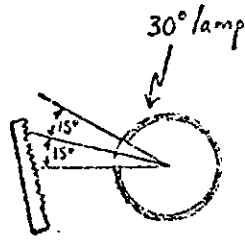
ClibPDF - www.fastio.com





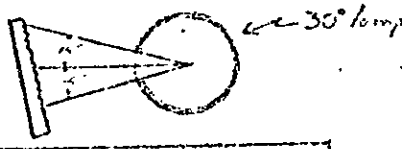
NOTE: LAMP LENS APERTURE SET AS SHOWN BELOW FOR CORRESPONDING TESTS.

Protetype Fixture
Inside Painted Black
Holophane Lens
5-29-66



I. Lens aperture of lamp beam at 15° up.

POSITION	1	2	3	4	5	6	7
TOP	200	195	200	235	200	205	305
CENTER	500	540	570	575	550	570	635
BOTTOM	245	265	255	310	345	380	225



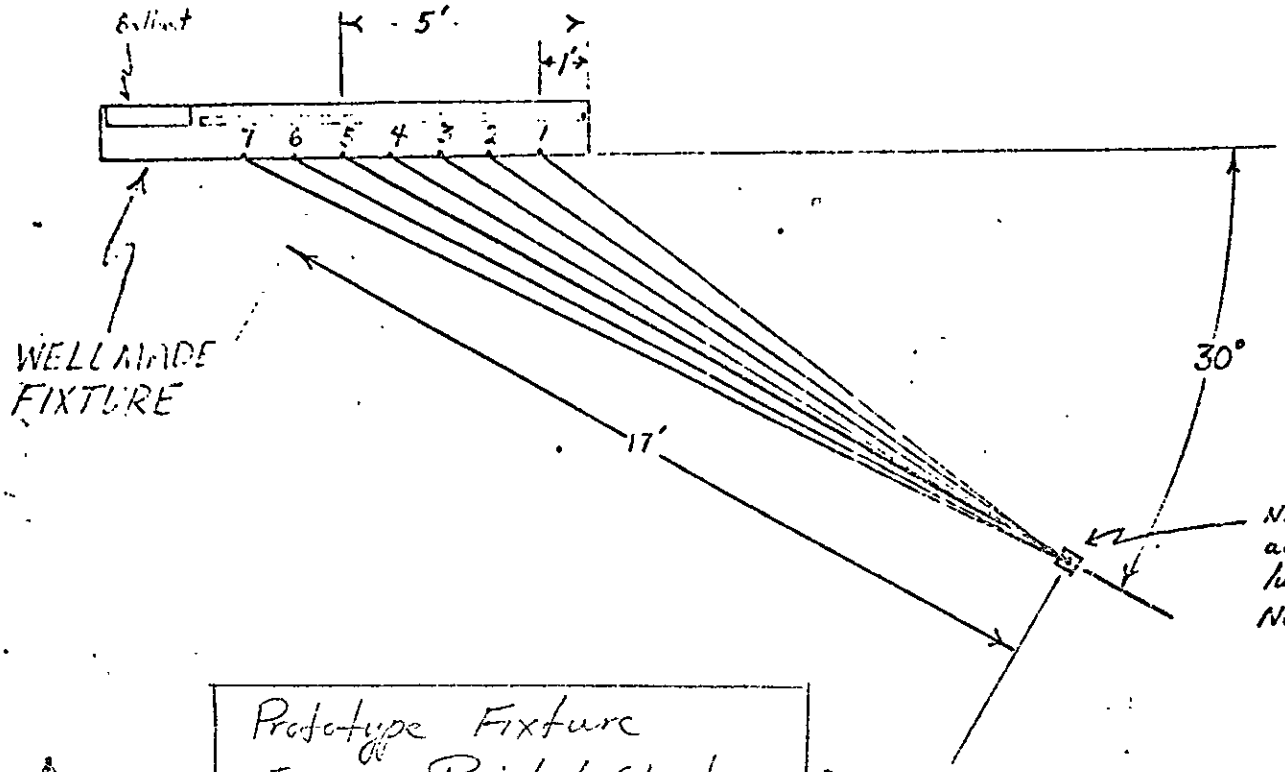
II. Lens aperture of lamp beam at 0°

POSITION	1	2	3	4	5	6	7
TOP	210	170	190	205	190	195	280
CENTER	435	505	525	575	580	610	575
BOTTOM	220	225	220	265	295	270	295

LENS BRIGHTNESS IN FOOT LAMBERTS

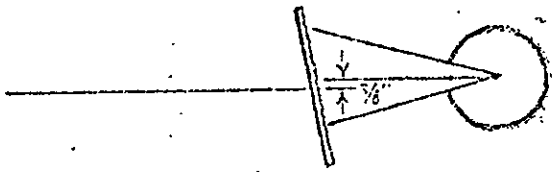
Figure 1

FORM TX-501D
ClibPDF - www.fastio.com



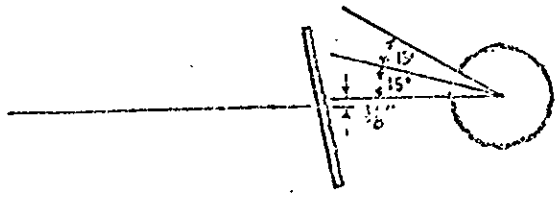
Prototype Fixture
Inside Painted Black
Holophane Lens
8-29-66

FORM TX-331D



I. Lens aperture of lamp beam at 0°.

POSITION	1	2	3	4	5	6	7
TOP	105	90	85	70	70	70	11
CENTER	10	10	10	13	12	11	5
BOTTOM	10	8	9	7	7	6	5



II. Lens aperture of lamp beam at 15° up.

POSITION	1	2	3	4	5	6	7
TOP	120	110	100	85	80	80	14
CENTER	11	11	11	15	11	14	5
BOTTOM	11	10	10	8	8	7	5

LENS BRIGHTNESS IN FOOT LAMBERTS

Figure 2

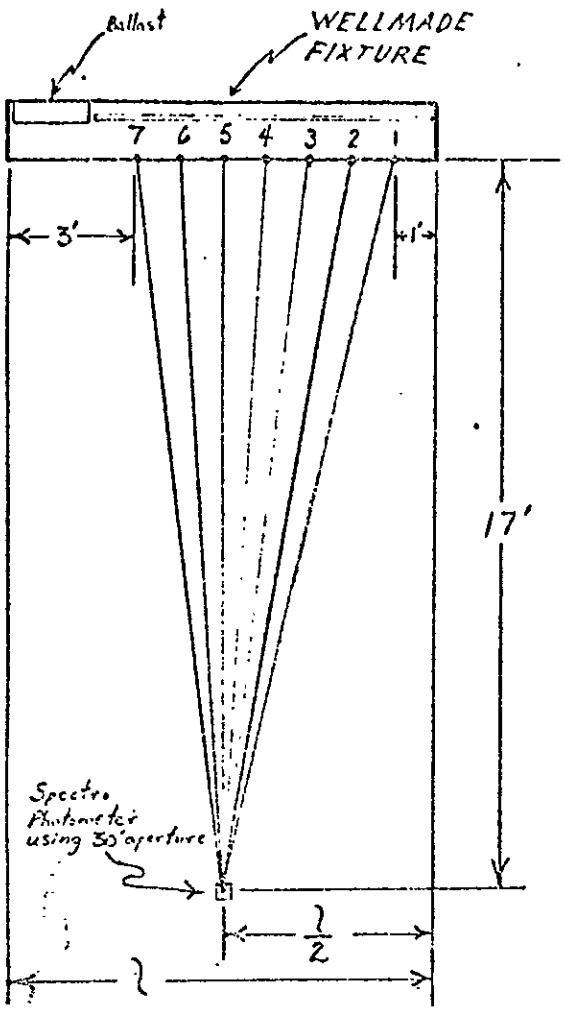
ClibPDF - www.fastio.com

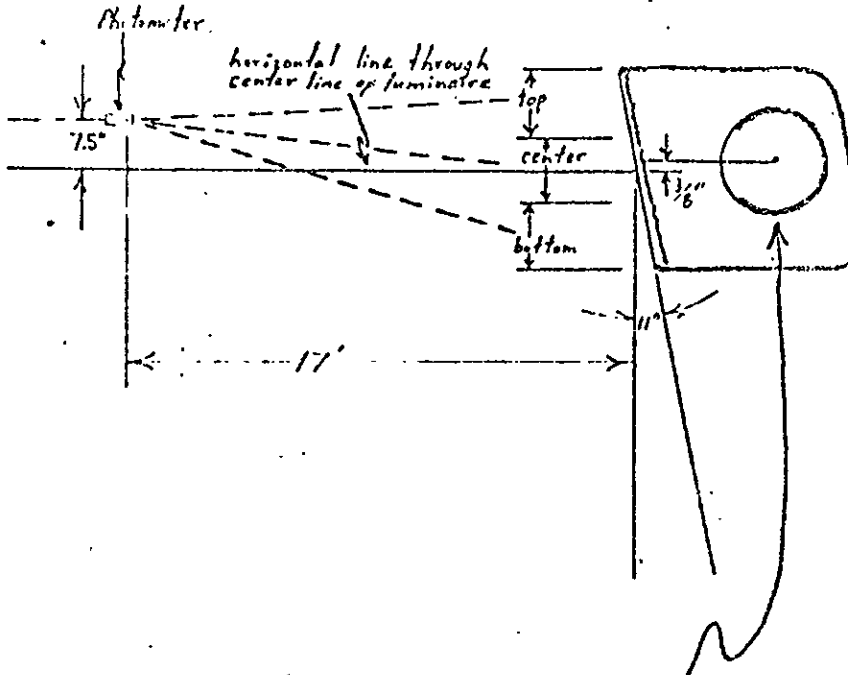
Prototype Fixture
Inside Painted Black
Stimsonite Lens
8-29-66

Candlepower Distribution
Horizontal Angle — 90°

Vertical Angles		Lamp Aperture: Horizontal — Right	Horizontal — Left	Horizontal — Average		15° Above Horiz. — Right	15° Above Horiz. — Left	15° Above Horiz. — Average
	+10°	365	430	400		265	290	275
	+5°	505	435	470		540	500	520
	0°	695	1220	960		610	625	615
	-2°	2880	1935	2910		710	1240	975
	-4°	3590	3715	3625		2160	3300	2730
	-5°	3770	2560	3175		3440	3655	3550
	-6°	2970	1775	2370		3680	3700	3690
	-7°	1800	1550	1675		3730	3310	3520
	-8°	1620	1550	1585		2610	1770	2190
	-9°	1520	1445	1485		1780	1670	1725
	-10°	1440	1285	1360		1575	1555	1565
	-12°	1120	1155	1125		1290	1215	1250
	-16°	390	245	320		590	460	525
	-20°	90	95	95		90	100	95
	-25°	65	65	65		70	75	75
	-35°	60	60	60		55	60	60
	-45°	55	55	55		55	55	55

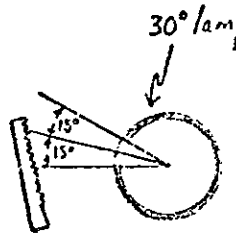
ClibPDF - www.fastio.com





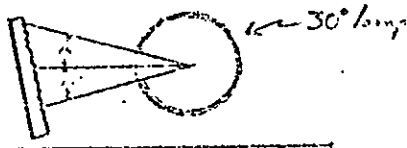
NOTE: LAMP LENS APERTURE SET AS SHOWN BELOW FOR CORRESPONDING TESTS.

Prototype Fixture
Inside Painted Black
Stimsonite Lens
9-29-66



I. Lens aperture of lamp beam at 15° up.

POSITION	1	2	3	4	5	6	7
TOP	140	155	155	160	160	170	195
CENTER	455	530	540	580	605	625	620
BOTTOM	260	285	285	305	380	320	350



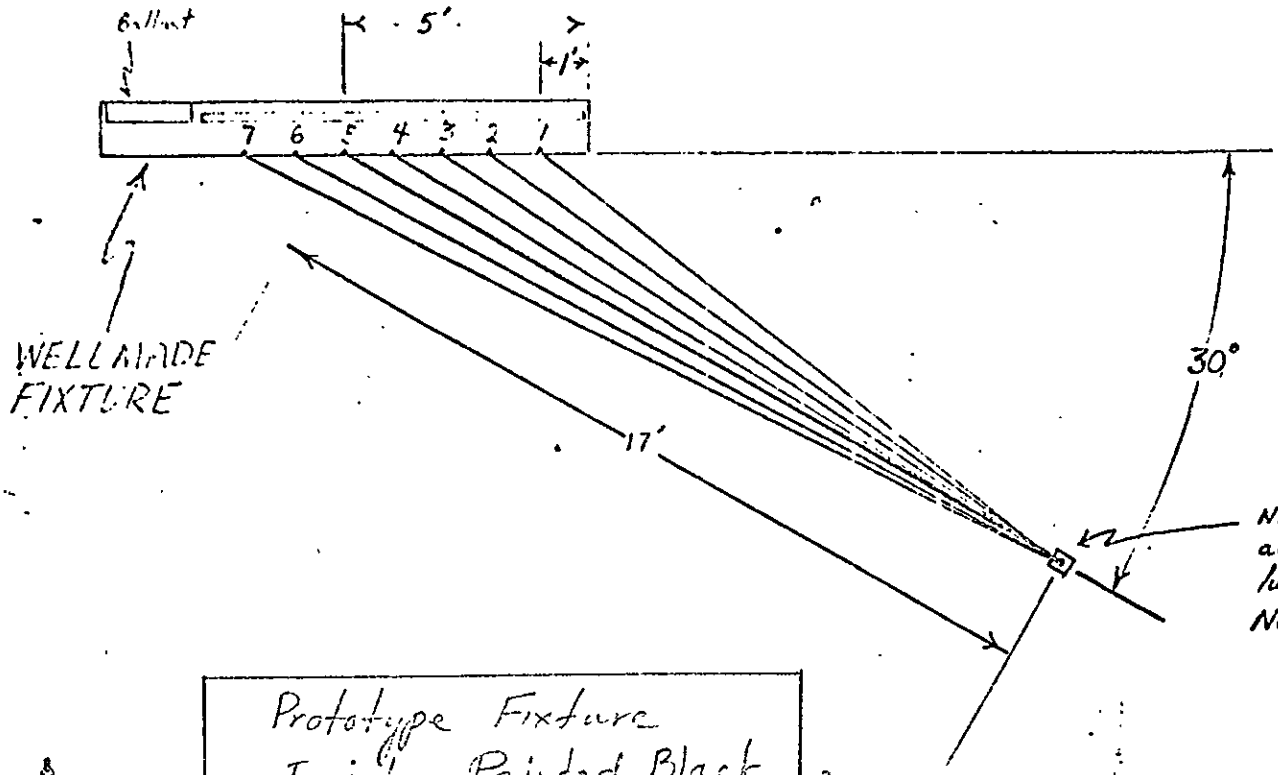
II. Lens aperture of lamp beam at 0°

POSITION	1	2	3	4	5	6	7
TOP	165	170	180	195	180	200	205
CENTER	510	605	620	660	685	735	700
BOTTOM	290	350	350	385	340	370	430

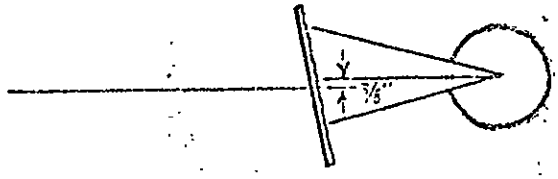
LENS BRIGHTNESS IN FOOT LAMBERTS

Figure 1

FORM TX.3010
ClibPDF - www.fastio.com

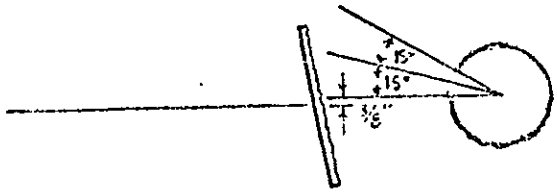


Prototype Fixture
Inside Painted Black
Stimsonite Lens
9-29-66



I. Lens aperture of lamp beam at 0°.

POSITION	1	2	3	4	5	6	7
TOP	90	70	70	100	95	60	35
CENTER	13	13	11	13	13	14	11
BOTTOM	14	11	11	11	10	7	7



II. Lens aperture of lamp beam at 15° up.

POSITION	1	2	3	4	5	6	7
TOP	95	65	55	110	75	60	35
CENTER	13	13	14	13	10	13	10
BOTTOM	12	8	10	10	7	7	7

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Figure 2

FORM TX-301D
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Prototype Fixture
Holophane Lens

Lampholder Raised 1/4"
Lamp Current 430 ma.
Values in Candles

9-2-66

CHECKED BY
APPROVED

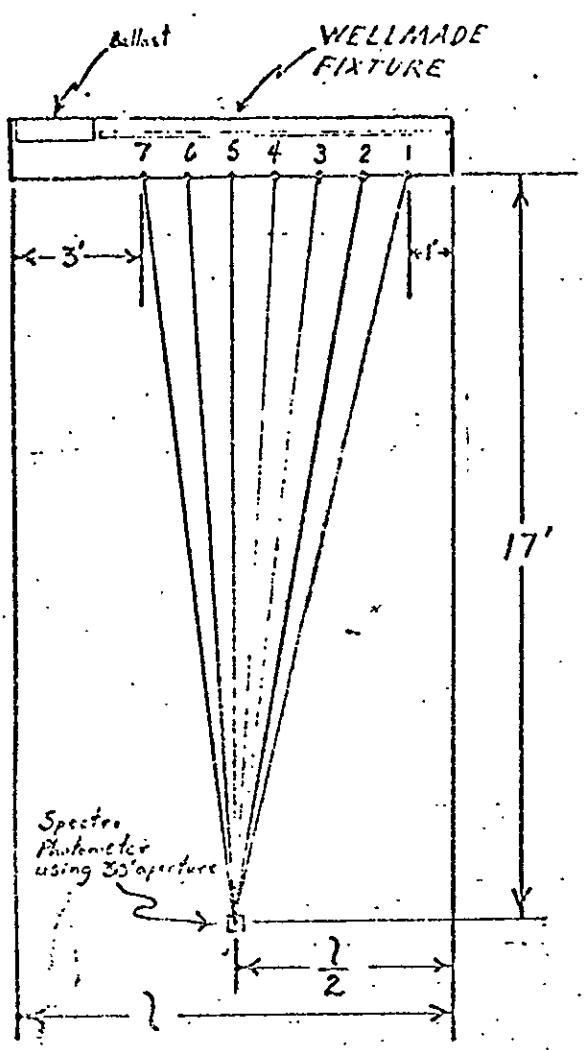
JOB

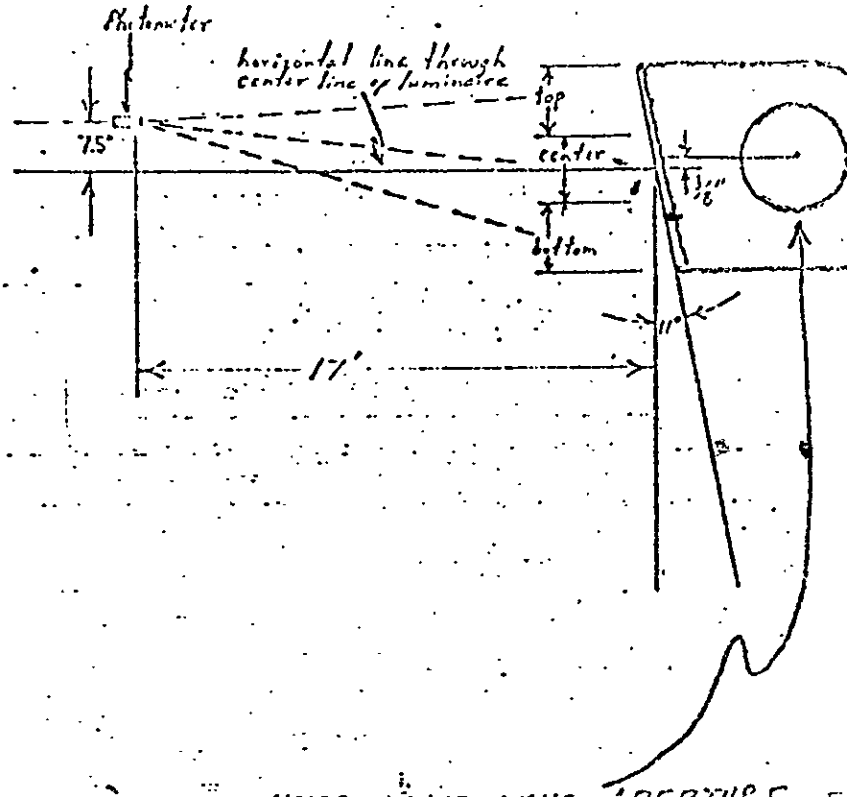
DEPARTMENT OF PUBLIC WORKS
DIVISION OF
SAN FRANCISCO BAY TOLL CROSSINGS

Vertical Angles	Horizontal Angles													
	90°	85°	80°	75°	70°	65°	60°	55°	50°	45°	40°	30°	20°	10°
+10°	420	410	390	370	340	310	280	230	180	130	100	65	40	10
-5°	770	760	730	670	600	520	430	330	250	190	140	80	40	15
0°	850	840	800	730	650	570	480	410	320	220	150	85	45	15
-2°	990	980	920	860	780	690	600	500	370	230	160	85	45	15
-4°	1960	1840	1740	1570	1360	1160	920	690	450	270	160	85	45	15
-5°	3100	3050	2850	2510	2110	1700	1260	850	500	270	160	85	45	15
-6°	3190	3450	3190	2830	2390	1900	1410	950	540	290	170	85	45	15
-7°	3700	3670	3490	3070	2590	2100	1580	1120	660	320	180	85	45	15
-8°	3900	3900	3230	2950	2580	2080	1580	1160	750	440	200	85	45	15
-9°	2800	2850	2750	2540	2260	1950	1580	1200	820	510	240	90	45	15
-10°	1970	1970	[illegible]	1820	1700	1540	1360	1120	870	590	340	95	45	15
-12°	1610	1610	1550	1450	1300	1160	1040	910	740	640	380	120	45	15
-16°	1000	1000	990	970	950	870	730	610	580	570	400	250	45	15
-20°	450	450	440	440	460	500	570	570	460	380	350	210	50	15
-25°	350	350	340	330	310	290	290	310	400	370	270	180	90	15
-35°	250	250	250	240	230	210	190	190	170	170	210	140	65	10
-45°	190	190	190	180	170	160	150	140	140	130	120	130	55	10

FIGURE 3

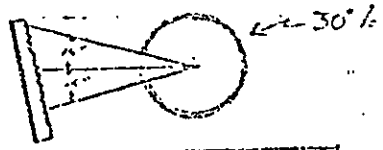
GitHubPDF - www.fastio.com





NOTE: LAMP LENS APERTURE SE
AS SHOWN BELOW FOR CORRESPONDING
TESTS.

Prototype Fixture
with Holophane Lens
Lamp holder Raised 1/4"
9-2-66



II. Lens aperture of lamp beam at 0°

POSITION	1	2	3	4	5	6	7
TOP	340	370	360	360	360	360	380
CENTER	430	480	420	570	670	700	660
BOTTOM	340	420	410	510	480	500	470

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Figure 1

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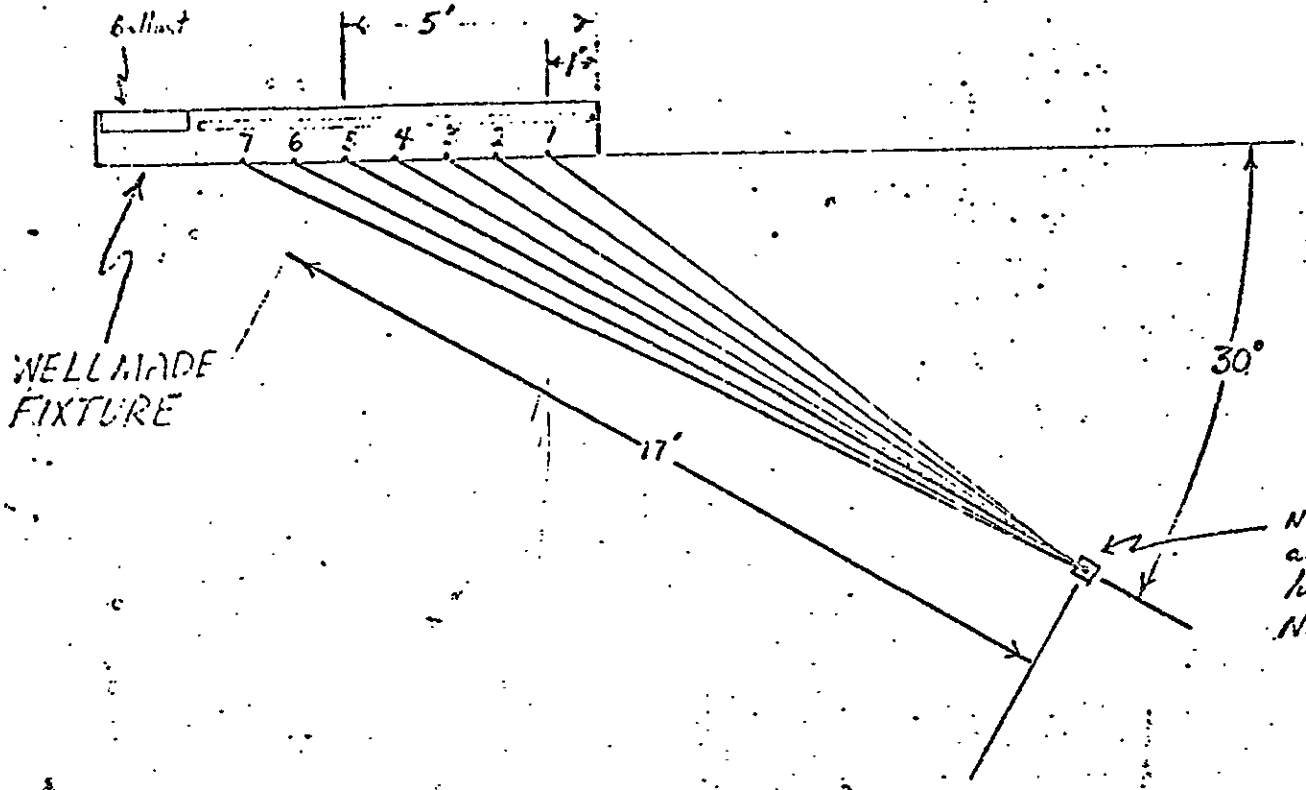

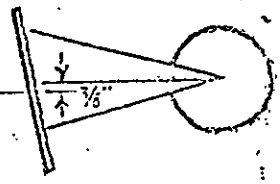

FORM TX-3010

I. Lens aperture of lamp beam at 0°.

POSITION	1	2	3	4	5	6	7
TOP	250	190	160	160	160	120	30
CENTER	21	23	21	22	20	18	10
BOTTOM	20	21	16	14	17	15	7

Prototype Fixture with Holophane Lens Lamp holder Raised 1/4" 9-2-66

* LENS BRIGHTNESS IN FOOT LAMBERTS

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